Oceaneering Space Systems, Inc.

Robotic End Effector for Inspection of Storage Tanks

Technology Need:

To assess the structural integrity of waste storage tanks, it is necessary to detect cracks and corrosion damage in the wall and weld joints. The tank environment precludes human inspectors, so teleoperated robots will be deployed through the tank riser access holes. It is desirable to inspect as much of a tank wall surface as possible in as little time as possible. The minimum defect of interest is a corrosion pit .125" in diameter by .125" deep. The solution to this need is the development of a robotic end effector to perform non-destructive evaluation (NDE) in conjunction with a simultaneous visual examination by the operator.

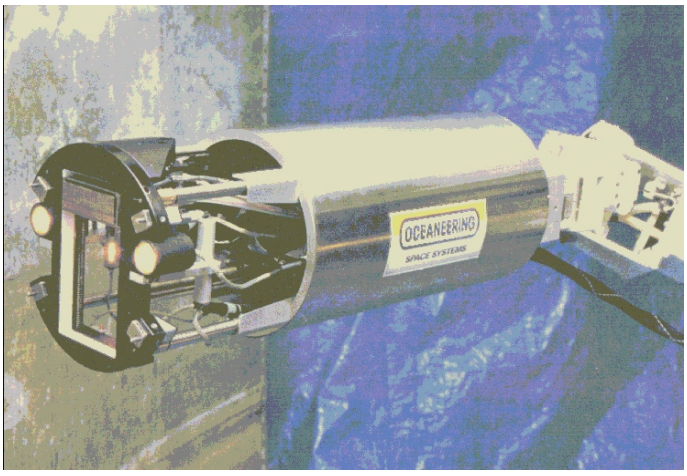
Technology Description:

Alternating Current Field Measurement (ACFM) is an electromagnetic NDE technique that has been specifically developed to overcome the shortcomings of eddy-current techniques. ACFM combines the ability of the Alternating Current (AC) Potential Drop technique to size defects without prior calibration with the ability of eddy-current to work without electrical contact. This is achieved by inducing a uniform AC field in the target material and measuring the magnetic fields above the specimen. The uniform current flow is modeled analytically, which allows the characterization and sizing of defects without the use of artificial defect samples to calibrate the system. The use of the uniform field encourages the production of arrays of coils to cover large areas simultaneously even when relatively small defects are targets.

ACFM does not require electrical contact or a couplant interface with the tank wall surface. The Robotic Tank Inspection End Effector (RTIEE) can be used to inspect large areas of a tank wall by translating, or "flying", it across the surface. The standoff distance and fly-by rate are determined by the size of the target defect. The current capability is to detect a fatigue crack while flying at 1 inch/sec. with a 1 inch standoff. On-going development efforts will result in the same detection capability at a 2 inch/sec inspection rate. The area inspected is 6 inch wide swath.

For detailed quantified inspections, the RTIEE scanning head is positioned against the tank wall and remains stationary during the NDE. The RTIEE's scanning head is designed to self-align with the wall as the manipulator pushes the end-effector against the wall surface. All data is logged electronically and tied to the manipulator position data. A full record of current and previous inspections is kept as a "Tank Wall Map".

The scanning frame is mounted to allow the manipulator to push the scanning frame up against the tank wall to guarantee sufficiently accurate array alignment with the wall. The video camera is mounted on the centerline of the end effector, thus providing both a primary view for the operator to drive the manipulator around the tank and a direct view of the inspected area within the scanning frame. The operator is provided with both live video and the results of the ACFM inspection on the same monitor. The ACFM of appraisal of the wall is presented as a two dimensional false color plot indicating defect position and size.



Benefits:

▸ Monitor the structural integrity of waste storage tanks using the Light Duty Utility Arm (LDUA) or other deployment system

▸Single compact end-effector combines tank video and lighting with an NDE technology that can detect and size cracks and corrosion pitting in any conductive material in real time

▸Advanced ACFM NDE technique has several advantages over traditional NDE techniques

▸ACFM does not produce secondary waste, unlike ultrasonic NDE which requires a sound couplant material

▸ACFM is a benign electromagnetic technique, unlike X-Ray which uses a hazardous source

▸ACFM can detect and size defects and is much less sensitive to standoff and orientation than eddy current; ACFM works thorough most coatings including paint, epoxy, rubber, etc.

Status and Accomplishments:

This project was completed in November 1999. The non-destructive examination end effector was then successfully deployed in a high level waste tank at the Idaho National Engineering and Environmental Laboratory (INEEL) in February 1999. A LDUA was deployed through a 12-inch riser into tank WM-188 for weld inspection. Tank WM-188 is an underground 300,000 gallon stainless steel tank, approximately 50 feet in diameter and 45 feet from riser top to tank bottom, containing a residual heel (about 10 inches deep) of high-level radioactive liquid waste.

A stereo video camera system was deployed for a preliminary visual inspection inside the tank followed by deployment of a Robotic End Effector for weld defect and corrosion inspection. No corrosion defects were noted on the three welds examined.

OSS also developed a sampling system capable of retrieving liquid and salt samples from difficult locations within a tank. The Tank Sampling and Inspection Tool (TMS # 2359), uses a lightweight, segmented mast equipped with a sample cylinder. The mast design allows the sampler to be assembled, then lowered to the proper depth inside the tank. The sample cylinders are designed to scrape and vacuum (the Vacuum Scarifying Sampling Tool Assembly, VSSTA), or cut core samples (Core Sampling tool) from the salt waste surface. This technology was deployed at SRS in 1998 in Tank 16H, a 1.0 million gallon high level waste tank that had leaked waste into its annulus. VSSTA retrieved samples of residual liquid on the tank bottom. The Coring Sampling tool retrieved samples from the annulus.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 278 & 2359
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

For additional information, please visit the Oceaneering International Inc.'s Internet address at http://www.oceaneering.com/

An Innovative Technology Summary Report (ITSR) for the Robotic End Effector technology is available at http://apps.em.doe.gov/ost/pubs/itsrs/itsr278.pdf